

June 4, 1929.

L. SMEDE

1,716,155

VACUUM RESPONSIVE GLOW TUBE CONTROL FOR RECTIFIERS

Filed Aug. 6, 1927

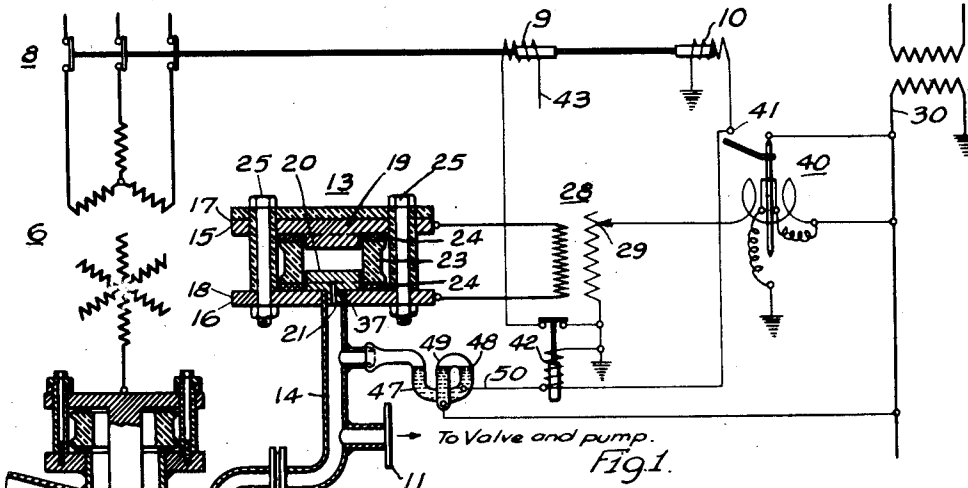


Fig. 2.

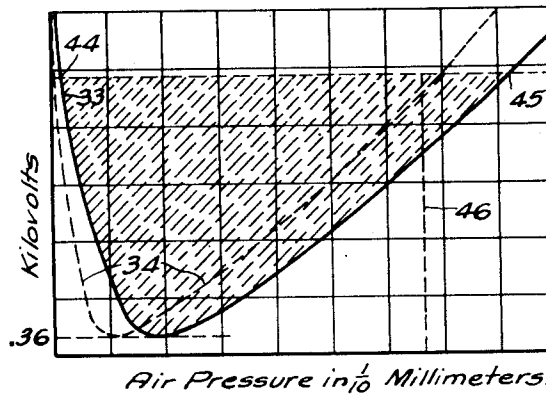


Fig. 3.

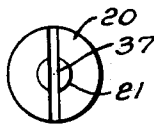
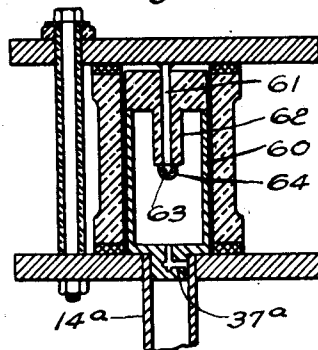


Fig. 4.



INVENTOR

Lloyd Smede.

BY

Wesley E. Smede
ATTORNEY

UNITED STATES PATENT OFFICE.

LLOYD SMEDE, OF PITTSBURGH, PENNSYLVANIA, ASSIGNOR TO WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY, A CORPORATION OF PENNSYLVANIA.

VACUUM-RESPONSIVE GLOW-TUBE CONTROL FOR RECTIFIERS.

Application filed August 6, 1927. Serial No. 211,104.

My invention relates to vacuum-responsive devices, and it has particular relation to means for obtaining an indication of an increase in gas pressure in an evacuated vessel.

The principal object of my invention is to provide means utilizing a glow-discharge device which is responsive to the vacuum in question and which breaks down upon the attainment of a predetermined gaseous pressure, as a means for obtaining an automatic response to a change in the degree of vacuum existing in an evacuated vessel.

A further object of my invention is to provide an auxiliary means, associated with the means just mentioned, for the purpose of operating in response to still further increases in the gas pressure and before the glow-discharge device ceases to discharge as a result of said increased gas pressure.

With the foregoing and other objects in view, which will be readily understood from the following description and claims, my invention consists of the novel features and combinations hereinafter described and claimed and illustrated in the accompanying drawing, wherein

Figure 1 is a diagrammatic view of circuits and apparatus embodying my invention in a preferred form, some parts of the device being indicated in section and other parts being indicated diagrammatically;

Fig. 2 is a curve diagram which will be subsequently referred to;

Fig. 3 is a bottom plan view of the central portion of the bottom electrode of my improved glow-discharge device; and

Fig. 4 is a cross-sectional view of a different form of glow-discharge device.

My invention is particularly adapted to the automatic control of a metal-tank mercury-arc rectifier which is indicated at 4 on the drawing. The rectifier is supplied with energy, in the usual way, from the secondary member of a main transformer 6 which is energized through a high-tension oil switch 8. The oil switch is provided with closing and opening coils 9 and 10, respectively. The rectifier tank is either continuously or intermittently evacuated by means of a pumping system which is connected at 11, so as to operate normally at a gas pressure no greater than a few microns of mercury. The pumping system is not shown in detail, as any known or desired mechanism

for such purpose may be utilized within the spirit of my invention.

I have provided a novel glow-discharge mechanism 13 which is connected to the rectifier tank by means of a pipe 14. The glow-discharge device consists of upper and lower electrodes 15 and 16, each comprising a base portion 17 and 18 and a flat-topped central knob or projection 19 and 20, respectively, the two projections extending toward each other and separated by any desired distance such as an inch or less. For convenience in manufacture, the bottom electrode 16 is made in two pieces, the central knob portion 20 being made in the form of a separate plug having a depending projection 21 fitting into the pipe 14.

The two electrodes 15 and 16 are held in spaced relation by a tubular insulating member 23, which may be of glass or porcelain, and which surrounds the knobs 19 and 20 with as close a fit as is mechanically feasible, for a purpose to be hereinafter mentioned. The tubular insulating member 23 is spaced from the base members 17 and 18 of the respective electrodes by means of rubber gaskets 24, or other means for effecting a vacuum-tight joint, said gaskets being compressed by means of insulated bolts 25. The problem of effecting a good vacuum-tight joint is very simple because the device always operates at room temperature.

An electromotive force of the order of 500 to 5000 or more volts is applied across the electrodes 15 and 16 by means of a step-up transformer 28 which may be provided with voltage-changing means 29 for the purpose of adjusting the pressure at which the glow-discharge device begins to operate. In the embodiment of my invention shown in the drawings, the step-up transformer 28 is energized from the auxiliary 110-volt alternating-current bus 30 of the rectifier station.

When a glow-discharge device operates under variable conditions of voltage, vacuum and electrode-spacing, different break-down voltages are obtained for different voltages, gas pressures and electrode spacings, according to the gaseous ionization in the space between the electrodes. If the vacuum is sufficiently high, the electrons, in passing from one electrode to the other under the influence of the electrostatic field or applied voltage, do not encounter enough gas molecules to produce the ionization necessary to

initiate the glow discharge. On the other hand, if the gas pressure, or number of gas molecules, is too great, the electrons are stopped by collisions with gas molecules before the electrons have had an opportunity to attain a velocity necessary to produce ionization by collision.

In Fig. 2, I have plotted a curve 33 showing the relation of the break-down voltage to the air pressure, in a particular gap device having electrodes spaced about one inch apart, although it will be understood that I am not limited to the specific values so indicated. It will be noted that, for the relatively high vacua, or low pressures, it requires relatively high voltages to break down the gap. As the pressure increases, the break-down voltage rapidly falls to a minimum break-down voltage which may be of the order of 360 volts, and as the air pressure still further increases, the break-down voltage again rises, but at a more gradual rate.

For gaps which are spaced a greater distance than that corresponding to the curve 33, or for points along the sides of the electrodes which are spaced a greater distance apart, the gap breaks down at lower air pressures, as indicated by the dotted-line curve 34, because of the greater opportunities for collision which are obtained by reason of the longer distance which an electron travels in passing from one electrode to another. It is noted that the same minimum discharge voltage is obtained with the different spacing of the electrodes, but that in every case any given break-down voltage is obtained at a lower air pressure for the more widely separated gap electrodes.

It is for the reason above explained that I have constructed my electrodes 15 and 16 with effective portions 19 and 20 which fit as closely as possible into the tubular insulating members 23, in order to prevent the breaking down of the gap by reason of the variable discharge distances of electrons attempting to pass from the sides of one electrode to the sides of the other.

In like manner, I have provided the central plug near 20 of my lower electrode with a slot 37 extending up to a point above the flange or base member 18 of the lower electrode, as shown in Figs. 1 and 3, in order to provide a restricted tortuous path connecting the gap space with the pipe 14, or, in general, a path within which no electric field exists and so shaped as to collect all ions and electrons, so that electrons cannot travel from the upper electrode 19 to points at various distances along the inside of the pipe 14.

In order to provide an indication of the break-down of the discharge gap, I have provided an electro-responsive relay 40, which may be a current relay or, as shown in the drawing, a watt-responsive relay,

which closes a contact 41 in response to the small amount of energy which is consumed in the glow-discharge device when a glow-discharge current is passing therethrough.

The relay is preferably placed in the primary circuit of the step-up transformer 28 because of the larger currents therein available, the secondary discharge currents being only of the order of a few milliamperes at some 5000 volts. The relay 40 is also preferably of a sluggishly acting type because, when the glow discharge device begins to operate, the discharge flickers somewhat and it is desirable to prevent the relay from opening and closing a large number of times before it finally moves to its steady-state position.

The relay contact 41, when closed, is utilized to energize the opening coil 10 of the main switch 8, to shut down the rectifier in response to a predetermined rise in the gas pressure within the rectifier tank.

The closing of the contact member 41 also energizes a lock-out relay 42 which deenergizes the closing coil 9 of the main switch 8, said closing coil having a supply conductor 43 which leads to the control equipment (not shown) provided at the sub-station.

In operation, the rectifier may be shut down by the glow-responsive relay 40 if the pressure increases to any predetermined value such as that corresponding to a mercury column of 15 or 20 microns.

It will be observed that the particular preferred form of glow-discharge device which I have designed, is made of massive iron parts and a massive tubular insulator member such as the insulators used in the rectifier tank itself. It is evident, therefore, that I have provided a vacuum-measuring device 13 which is no more susceptible to breakage or injury than the anode holders of the rectifier itself.

While I have shown my glow-discharge device as being located on a pipe which bends out from the tank, it will be understood that such illustration is only for convenience in showing the apparatus in a single figure. In an actual rectifier tank, the glow-discharge device is located above the top plate of the tank, either between two of the anodes or within the circle of the anodes of the tank.

It will be noted from Fig. 2, that with nearly 5000 volts electrical pressure applied to the electrodes, my glow-discharge device will break down when the air pressure rises to a certain value, as indicated at 44 in the figure, and the glow will continue to discharge, as the air pressure still further increases, until the point 45 is reached, after which the break-down voltage, which is substantially the same as the voltage necessary to sustain the glow discharge after it is once initiated, becomes higher than the applied

electrostatic potential and hence the glow discharge is discontinued.

If a rectifier is shut down by the operation of my relay 40, in response to poor vacuum conditions such as may be caused by a leak, it may be that during the interval in which the cause of shut-down is being investigated by the attendants of the plant, the pressure may increase beyond the point 45, so that the relay 40 opens and either automatically starts the tank again or at least permits the tank to be started in case an attempt should be made thereafter to restart the rectifier.

In the actual installation, as I have designed it, the operation of the relay 40 is utilized to trip out the trip coil of a master controller such that the plant cannot be again started without manual manipulation, if the vacuum is so poor as to cause the operation of the said relay 40, and it is expected that no operator will attempt to restart the rectifier without assuring himself as to the proper vacuum conditions.

However, to make the device absolutely fool-proof, it is possible to add an attachment which is responsive to pressures of the order of one-half millimeter or a millimeter of mercury, in order to operate at a point, as indicated at 46 in Fig. 2, while the glow-discharge device is still functioning and before the glow is interrupted by an increase in pressure beyond the point 45 in Fig. 2. Such a device may be a simple manometer or mercury switch, as indicated at 47 in Fig. 1, in which a mercury column 48 spills over and makes contact with a second mercury column 49 in response to excessive increases in the gas pressure to be measured. By this means, a circuit 50 is established to the lock-out relay 42 hereinabove described.

While I have described a form of glow-discharge device 13 substantially as I have constructed it in actual practice, it may be found that it will have more constant operating characteristics by being constructed on the point-to-cylinder discharge principle, as indicated by way of example, in Fig. 4, wherein a cup-like metal electrode 60 is provided instead of the solid electrode 20 of Fig. 1, the other electrode being an axially depending wire 61 which is tightly enclosed by an insulating sleeve 62, except for the extreme tip 63 of the wire, which is exposed. A tip 64 of carbon or graphite is preferably pushed over the wire tip 63 in order to preserve its life. The glow-discharge space is connected to the pipe 14^a by a tortuous path 37^a. It will be understood that the construction, in Fig. 4, is otherwise similar to that shown in Fig. 1.

In operation, the glow-discharge device of Fig. 4 provides a very sharp breakdown at, or near, the surface of the "point" or small electrode 64. By reason of the highly

concentrated field in the region of the "point" electrode, the device may be found to be much more sensitive to changes in pressure than a device in which the field is uniform, although the latter device has proved to be successful in operation. A peculiarity of the operation of the point-discharge device, which may, in some respects, be considered disadvantageous, is that it is a rectifying device and hence, unless two oppositely conducting devices are utilized, requires a somewhat more slowly acting, and hence more expensive, relay than the non-rectifying glow-discharge device 13 of Fig. 1, in order to prevent "chattering" upon the occurrence of a discharge.

While I have specifically described and explained my invention in relation to a particular form of embodiment, I desire to be understood that such particular description and explanation is only suggestive and not intended by way of limitation. It is desired, therefore, that the appended claims shall be accorded the broadest interpretation consistent with their language and the prior art.

I claim as my invention:

1. A vacuum-responsive mechanism comprising a glow-discharge device having spaced electrodes operating in the vacuum in question, a source of electromotive force higher than the minimum glow-discharge breakdown voltage applied to said electrodes, the applied electromotive force and the electrode spacing being such that no glow discharge can take place during normal vacuum conditions, and electrical-energy responsive means for operating in response to the flow of a glow-discharge current in said glow-discharge device.

2. The combination with a vessel normally having a vacuum corresponding to a gas pressure no greater than a few microns of mercury, of a mechanism associated therewith and responsive to a predetermined increase in the gas pressure therein, said mechanism comprising a glow-discharge device having spaced electrodes operating in the vacuum in question, a source of electromotive force higher than about 360 volts applied to said electrodes, the applied electromotive force and the electrode spacing being such that no glow discharge can take place during normal vacuum conditions, and electrical-energy responsive means for operating in response to the flow of a glow-discharge current in said glow-discharge device.

3. The combination with a vessel normally having a vacuum corresponding to a gas pressure no greater than a few microns of mercury, of a mechanism associated therewith and responsive to a predetermined increase in the gas pressure therein, said mechanism comprising a glow-discharge device having spaced electrodes operating in the

vacuum in question, a source of electromotive force higher than about 360 volts applied to said electrodes, the applied electromotive force and the electrode spacing being such that no glow discharge can take place during normal vacuum conditions, electrical-energy responsive means for operating in response to the flow of a glow-discharge current in said glow-discharge device, and additional means operating in response to still further increases in the gas pressure and before the glow-discharge device ceases to discharge as a result of said increased gas pressure.

4. A vacuum-responsive mechanism adapted to operate in response to an increase in gas pressure above values corresponding to a relatively good vacuum, said mechanism being characterized by having two electrodes, a tubular insulating member separating said electrodes, a vacuum-tight joint between each electrode and said insulating member, and a pipe connected to the discharge gap through a path within which substantially no electric field exists, said path being tortuously shaped whereby it will collect all ions and electrons.

5. A vacuum-responsive mechanism adapted to operate in response to a change in gas pressure, said mechanism being characterized by having two electrodes, each having a base portion and a flat-topped central knob or projection extending toward the other electrode, a tubular insulating member separating the base portions of said electrodes and closely surrounding said knobs, a vacuum-tight joint between each electrode and said insulating member, and a pipe connected to the discharge gap through a restricted, tortuous path.

6. A vacuum-responsive mechanism comprising a glow-discharge device having spaced electrodes operating in the vacuum in question, a source of electromotive force higher than about 360 volts applied to said electrodes, a slow acting electrical relay for operating in response to the flow of a glow-discharge current in said glow-discharge device, and apparatus arranged and adapted to be controlled in response to said relay.

7. A vacuum-responsive mechanism comprising a glow-discharge device having electrodes operating in the vacuum in question, a source of electromotive force higher than about 360 volts applied to said electrodes, a sluggishly responsive electrical relay for operating in response to the flow of a glow-discharge current in said glow-discharge device, means for varying the electromotive force of the said source, and apparatus arranged and adapted to be controlled in response to said relay.

8. The method of utilizing a glow-discharge device which is connected to a highly evacuated vessel for the purpose of securing an indication of poor vacuum in said vessel which comprises the application to said glow-discharge device of a voltage which is just sufficient to cause break-down of the glow-discharge device at the poorest permissible vacuum in said vessel, and obtaining an indication of the occurrence of any glow discharge which takes place in case the vacuum becomes poorer than said predetermined amount.

In testimony whereof, I have hereunto subscribed my name this 3rd day of August, 1927.

LLOYD SMEDE.